FINAL REPORT

From the Research Foundation of The City University of New York

To the Office of Naval Research

Modern methods in meteorological and oceanographic data analyses

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Background

The mission of the Earth and Atmospheric Sciences Department of The City College is to educate students in the basic principles of the atmospheric, earth and oceanic sciences so they have a thorough understanding of these environments and can apply the knowledge. To help acquire this knowledge, students are educated and trained to collect data, reduce the data into analyzable quantities, analyze the data into interpretable results, report the results and the conclusions.

Meteorological and oceanographic data systems are currently undergoing a revolution. The previously manual systems have been replaced by remote and in situ automatic systems. For example, weather observers at airports have been almost completely replaced with automatic measuring systems. The automatic systems generate large amounts of digital data that only can be manipulated with modern computing systems (an example of the large amounts of digital data are the weather satellite images commonly used by TV weather forecasters). These extensive streams of data are generated most often by government agencies (eg. National Weather Service, NWS) and utilized by government operational and research activities, universities and commercial enterprises. For our students to be prepared to enter this job market, they must become knowledgeable in the collection, manipulation and application of digital data.

Accordingly, our department is modernizing the weather station. We have been and continue to receive analogue weather data (eg. weather maps) from facsimile transmissions. However, with partial support from the National Science Foundation, we obtained in the Fall of 1990 a **U**niversity **D**ata **P**ersonal **C**omputer-**M**an computer **I**nteractive **D**ata **A**cquisition **S**ystem (Unidata PC-McIDAS). The system provides meteorological and oceanographic data by computer especially tailored for undergraduate and graduate atmospheric science institutions (Sherretz and Fulker, 1988, Fulker, 1989).

The initial Unidata system has served only one student at a time. Therefore, we needed to expand our system by developing a local-area-network so a number of students could simultaneously access the data. A local-area-network is a number of workstations connected to a host computer; the host computer receives the data that each workstation can access. We, also, needed to connect to regional and national networks to send and receive data and computer programs with colleagues world-wide. The networked system will enable us to manipulate and display weather data not only for our own department but for other teaching, research and service activities within City College. Domenico (1991) has described the design of the campus-wide weather system.

A unique feature of City College is its large population of students who are presently under represented in the atmospheric and oceanic sciences, in particular, and in the sciences, in general.

CCNY has probably the most ethnically diverse student body of any college in the country: 50% of the students are foreign born, they come from 80 different countries and as many as 50 different languages can be heard on the campus. The new data system will be used to educate and train a portion of these students, thereby increasing the population of qualified scientists (and, perhaps, engineers) from the under represented ethnic populations.

Technical Objectives

The first objective was to develop a network with the CCNY Unidata system to increase access to real-time data for our students in the atmospheric, earth and oceanic sciences.

The second objective was to integrate the system into the curriculum to educate students in the modern methods of data collection, reduction, analyses and interpretation.

The third objective was to evaluate the effectiveness of the new methods.

Technical Approach

The PC-McIDAS and the NWS analogue weather data currently are received at CCNY. The PC-McIDAS will replace the analogue system as the NWS completes its current modernization and terminates the analogue transmission. Consequently, we need to increase student access to PC-McIDAS. The necessary hardware and software were purchased to set up a local-area-network and connect with the national networks. The CCNY was awarded a 50% discount by IBM to purchase of a RISC 6000 workstation and communications software and hardware to develop the networks.

To integrate the PC-McIDAS into the curriculum, a new course *Microcomputers in Meteorology* was developed by the PI. Further, portions of the McIDAS data were integrated into existing meteorology courses to modernize the content.

The effectiveness of the digital data system was evaluated, in part, by having students perform an analysis by hand and, then, repeat the same analysis using the computer.

Technical Accomplishments

Networks

The development of the network was facilitated by hiring a part-time student systems operator (other research funds were used which involving the RISC 6000 because this contract did not fund a systems operator). The detailed knowledge of three operating systems (AIX, OS/2, DOS), the communications software (TCP/IP) and the applications software required the full-time attention of a

systems operator. Also, the systems operator was responsible for maintenance of the PC-McIDAS and McIDAS-X software (McIDAS-X is McIDAS for the RISC workstation). The systems operator position was a marvelous opportunity to introduce a physics major (Antony Galea) and a math major (Angel Gonzales) to the atmospheric and ocean sciences; they served as our system operators. They provided a detailed description of the system which is in Appendix A. The RISC workstation turned out to be a test-bed for developing future system operators.

The RISC system can be used to archive large quantities of meteorological data with the 8 mm (2.3 gigabyte) tape. Presently, we archive NWS facsimile weather maps plus data received from NWS on microfilm. We also archive certain satellite images and surface and upper-air data with the PC's for research purposes. The RISC will allow us to automatically archive data 24 h a day, 365 days a year, thus eliminating the need to archive the NWS weather maps and microfilm. Further, retrieval and manipulation of the archived digital data will be much easier that with the current analogue data.

Curriculum

The PI developed a course *Microcomputers in Meteorology* to teach the students to utilize the new system (see Appendix B). Satellite images, atmospheric soundings and cross-section analyses previously unavailable now facilitate learning in other meteorology courses: *Introduction to Meteorology, Operational Meteorology* and *Synoptic Meteorology*. The Unidata signal is now used as an integral data source and display for weather phenomena in forecasting and synoptic meteorology courses and student/staff daily weather briefings. With five PC's in our weather station/computer laboratory, computer programming, mostly in QuickBasic, forms an integral part of most advanced courses in the meteorology curriculum which include simple atmospheric modeling.

Evaluations

Evaluating the students hand analyses against those produced with the PC-McIDAS system was like comparing walking to traveling to the same location in a rocket. For instance, our students learn to plot and analyze upper air temperature, moisture and wind measurements on the adiabatic diagram to determine atmospheric stability and predict convective cloud formation. The students go through this process to understand where the data come from and how the data are manipulated to produce a useful analyses. It takes the average student about a hour to complete one sounding analyses. This same process is done by the same student in a matter of seconds by the PC-McIDAS! As a result, many soundings can be analyzed by the same student and, therefore, the student develops a better understanding of a particular meteorological situation.

The PC-McIDAS networked to the RISC revolutionized the way laboratories are conducted in the introductory meteorology course. For instance, in one laboratory the students learn to determine the cloud top temperatures from infrared satellite images analyzed with gray shades which correspond to temperatures. The students manually determine the temperatures by visually comparing the satellite image to a gray shade "wedge" calibrated according to temperature. This procedure is inaccurate because the shades on the satellite image and on the "wedge" are difficult to visually compare. Instead, the PC-McIDAS has a built in algorithm which relates brightness to temperature. Thus, a student merely has to place the cursor over a region of the cloud and type a command to see the infrared temperature displayed. Furthermore, with our five PC work stations connected to the RISC we only have to have five to six students at each station. Without the local network, we could not use the PC-McIDAS in our laboratory; it is impossible for 25 students to use one workstation during a lab period.

System spinoffs

Our department and the CCNY School of Education have begun a joint project with NSF support utilizing the networked PC-McIDAS to enhance science teaching at selected NYC primary and secondary schools.

The data acquired with PC-McIDAS substantially assisted our research in determining detailed features of ship-produced clouds the marine boundary layer as described by Hindman, et al., (1992); see Figure 1.

The properties of large-scale mountain cloud systems were determined using GOES images acquired with PC-McIDAS; the properties of cloud particles sampled from these clouds were determined using the PS-2's to process data from an image analysis system purchased with NSF funds as reported by Hindman (1993).

Development of a bulk microphysics model that explains both the form of precipitation (rain, snow, freezing rain, or ice pellets) in cyclonic storms and its thermal impact on the atmosphere was greatly facilitated by the speed of the RISC 6000 as reported by Gedzelman and Arnold (1993).

The PC-McIDAS was used to gather and analyzing data in a study of warm snowstorms; Joseph Paluszek was awarded 3rd place in the 1991 Father James B. Macelwane Award for undergraduate research in meteorology (American Meteorological Society) for his paper, *The Warm Snow Phenomenon*.

Software was development by the PI's colleague Prof. Stanley Gedzelman for use in meteorology courses. The software utilizes the superior graphics capabilities of the PS-2's to display and/or animate phenomena such as the dendritic growth of snowflakes, the

sunpath, the adiabatic chart and thermodynamic processes, air particle trajectories, optical phenomena such as rainbows and halos, and a simple climate model with factors that can alter climate.

Summary

The modernization of the CCNY weather station has be greatly facilitated by acquisition of the PC-McIDAS digital weather data system (NSF funding) and the RISC 6000 workstation (ONR funding) to network the PC-McIDAS workstations. The RISC workstation has expanded our research computing, archiving of weather data and networking to colleagues locally, regionally and worldwide. The system has revolutionized teaching in our meteorology courses; for example, satellite images now can be simultaneously displayed and analyzed by a number of students. The system is a training device for future meteorologists as well a computer system operators. The acquisition of the RISC system has expanded our weather station into a computer laboratory where a number of activities simultaneously occur: for example, **teaching** students to interpret satellite images, **researching** the cause of ship-produced clouds and **serving** the CCNY community by providing daily weather products.

References

Domenico, B., 1991: The Unidata campus weather display system. *Preprints 7th Intl. Conf. on Interactive Information Processing Systems for Meteorological, Oceanography and Hydrology*, Am. Meteor. Soc., Boston, pp. 454-458.

Fulker, D. W., 1989: Seminal software to analyze and manage geoscientific information (Unidata "building-blocks" for the scientist-programmer). *Preprints 5th Intl. Conf. on Interactive Information Processing Systems for Meteorological, Oceanography and Hydrology*, Am. Meteor. Soc., Boston, pp. 44-49.

Gedzelman, S. D., and R. Arnold, 1993: The form of cyclonic precipitation and its thermal impact. *Mon. Wea. Rev.*, in press.

Hindman, E. E., 1992: An undergraduate field course in meteorology and atmospheric chemistry. *Bull. Am. Meteor. Soc.*, in press.

Hindman, E. E., W. Porch, J. Hudson and P. Durkee, 1992: Ship-produced cloud line of 13 July 1991. *Proc. 11th Intl. Conf. on Clouds and Precipitation*, Montreal, Canada, August 17-21, 1992, pp. 184-187.

Sherretz, L. A. and D. W. Fulker, 1988: Unidata: Enabling universities to acquire and analyze scientific data. *Bull. Am. Meteor. Soc.* **69**, 373-376.

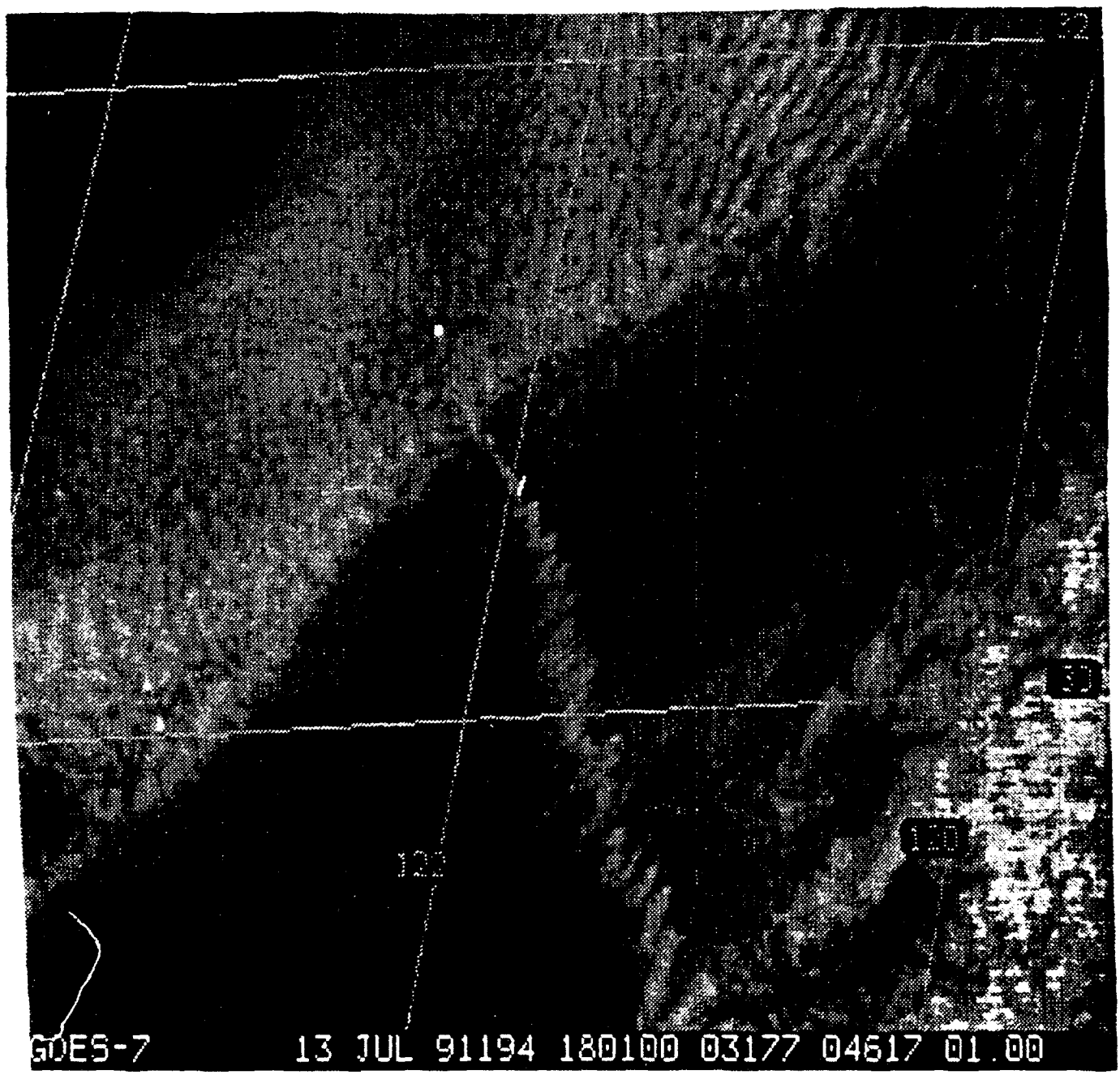


Figure 1. A dramatic ship-produced cloud on 13 July 1991 at 18Z captured by CCNY meteorology major Kwan Yin Kong using the geosynchronous orbiting environmental satellite (GOES) visible signal received with the CCNY PC-McIDAS system. The white square is the approximate position of the ship and the white line marks the location of *R/V Egabrag* transiting the ship plume as described by Hindman, et al. (1992)

APPENDIX A

The CCNY Weather Station and Computer Laboratory.

The weather station is an computerized laboratory supporting the research and educational needs of the City College meteorology program. Multiple users are allowed concurrent access to meteorological data and modeling programs. Bitnet access is also provided, enabling our staff to to exchange ideas, data, and programs with meteorologists throughout the world. The following is a brief technical description of the computer system.

The hardware on which the network is based, consists of one IBM RISC 6000 model 7013-520H Powerstation, two Austin 486-33VLi Winstations, and three IBM PS/2 386 model 70-A21's.

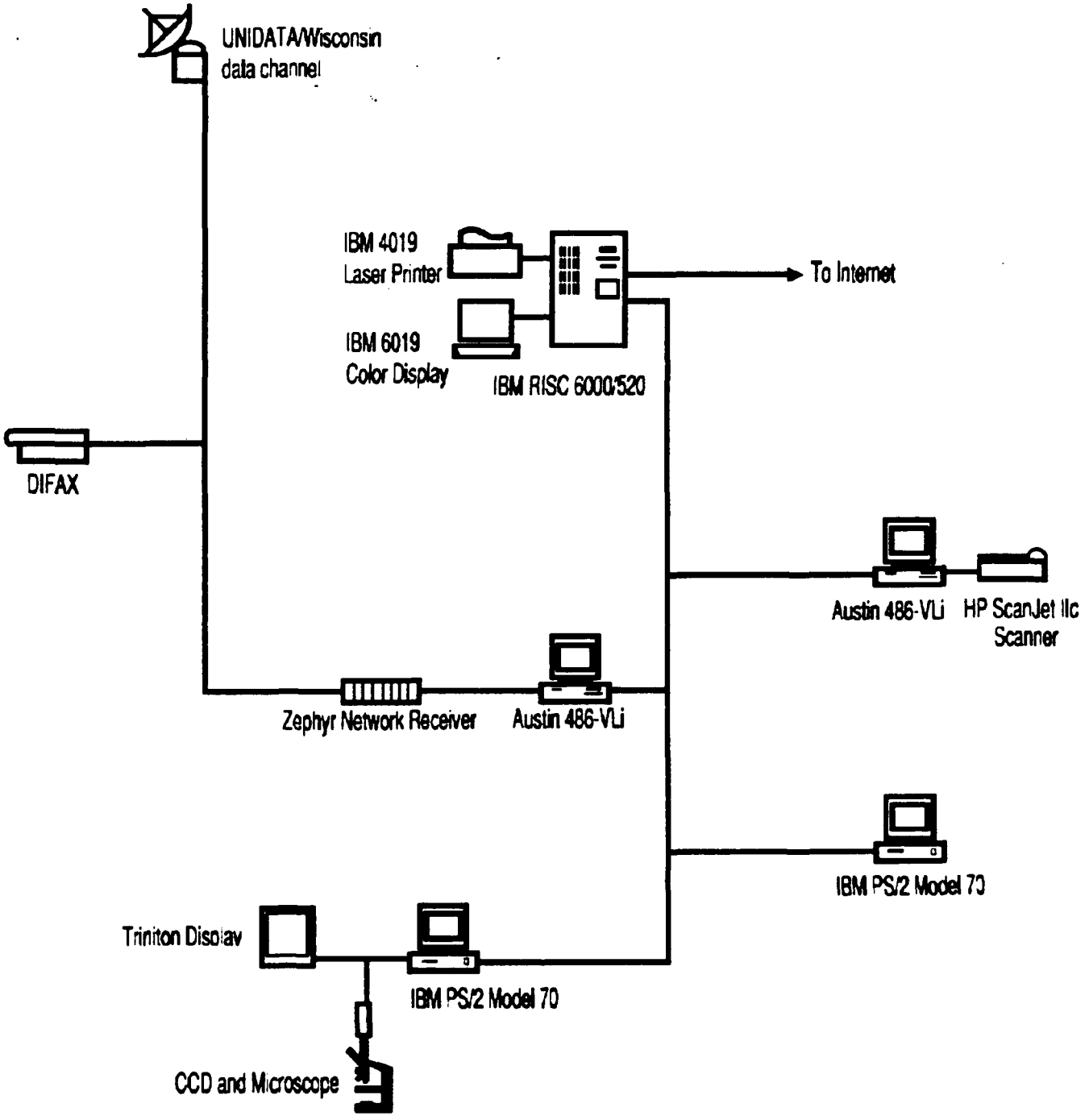
The network topology is a linear bus configuration (see diagram). The network protocol is TCP/IP and the implementation is IEEE 802.3 thin-net. The RISC 6000 is running AIX Version 3.2 and the PC's are running OS/2 2.0 and Windows 3.1.

The RISC 6000 is the file server and the print server. The RISC 6000 has a 670Mb hard drive for storage and an 8mm DAT device for backups and the archiving of data. There is also a CD-ROM drive which is used to access meteorological data that is commonly stored on CD-ROM due to its large volume. The attached printer is an IBM 4019 Post Script Laser Printer. This is used to print both documents and satellite images (see Figure 1 in text).

Weather data is collected from the Unidata/University of Wisconsin data channel by a Zephyr network receiver. The data is stored, displayed, and manipulated using Unidata McIDAS 5.60 on the OS/2 machines. McIDAS-X 1.60 is installed on the RISC 6000. This permits us to exploit the RISC's large storage capacity and provide McIDAS user with an Enhanced X-Windows working environment.

One of the PS/2's is connected to a video analysis system which is used to characterize cloud droplet distributions and provides sizing, counting and image enhancement facilities. One Austin computer is connected to a Hewlett Packard IIc color scanner. This can be used to prepare publications with embedded diagrams and to hand-enhance images. The scanner can be used to prepare "slide show" presentations and animated sequences of meteorological images.

Bitnet access is provided by a thin-net connection to the science divisions Vax 11/780. The Vax is a gateway to Internet and will give the weather station computers access to local (campus) and worldwide computer facilities. This gives the weather station computers the ability to download software from ftp (file transfer protocol) sites. Students and professors can access the weather station computers from any computer with a modem.



The CCNY Earth and Atmospheric Sciences Department meteorological, oceanographic and geological data system as of 10/9/92

APPENDIX B

SPRING 1992
EPS 316 MICROCOMPUTERS IN METEOROLOGY
Prof. W. Hindman, MWF 1100-1150h, J902

Meeting	Day	Date		Topic
1.	M	28	Jan	Organization / What is a microcomputer?
2.	W	30	Jan	Operating systems
3.	F	1	Feb	Operating system: DOS
4.	M	4	Feb	Operating system: DOS
5.	W	6	Feb	Data presentation: Word processing
6.	F	8	Feb	" " " "
7.	M	11	Feb	Data analyses: Spread sheets
8.	W	13	Feb	" " " "
9.	F	15	Feb	Image analysis system demonstration
10.	W	20	Feb	Data analyses: programming
11.	F	22	Feb	" " "
12.	M	25	Feb	Exam I
13.	W	27	Feb	Meteorology measurement systems
14.	F	1	Mar	" " "
15.	M	4	Mar	Unidata program/McIDAS overview
16.	W	6	Mar	Basic concepts
17.	F	8	Mar	" "
18.	M	11	Mar	Menu-mode lecture
19.	W	13	Mar	Menu-mode lab
20.	F	15	Mar	" " "
21.	M	18	Mar	Menu-mode function-key lecture
22.	W	20	Mar	Menu-mode function-key exercises
23.	F	22	Mar	" " "
24.	M	25	Mar	Command-mode lecture
25.	W	27	Mar	Exam II
SPRING BREAK!				
26.	M	8	Apr	Command-mode exercises
27.	W	10	Apr	" "
28.	F	12	Apr	" "
29.	M	15	Apr	Combined function-key & command-mode exercise
30.	W	17	Apr	" " " "
31.	F	19	Apr	" " " "
32.	M	22	Apr	Producing hard-copy
33.	W	24	Apr	Data archiving
34.	F	26	Apr	" "
35.	M	29	Apr	Networking
36.	W	1	May	"
37.	F	3	May	"
38.	M	6	May	Student projects
39.	W	8	May	" "
40.	F	10	May	" "
41.	M	13	May	Summary
42.	W	15	May	Exam III

Grading: Exams: 30%, Laboratory exercises: 70%

APPENDIX C

Publications which utilized the RISC 6000 and Unidata PC-McIDAS (copies attached):

Gedzelman, S. D., and R. Arnold, 1993: The form of cyclonic precipitation and its thermal impact. *Mon. Wea. Rev.*, in press.

Hindman, E. E., 1992: An undergraduate field course in meteorology and atmospheric chemistry. *Bull. Am. Meteor. Soc.*, in press.

Hindman, E. E., W. Porch, J. Hudson and P. Durkee, 1992: Ship-produced cloud line of 13 July 1991. *Proc. 11th Intl. Conf. on Clouds and Precipitation*, Montreal, Canada, August 17-21, 1992, pp. 184-187.